UDC 316.42+504+330.34

COMPOSITION OF AGGREGATE DEVELOPMENTAL RISK INDEX FOR SELECTED SUBSET OF COUNTRIES IN LATIN AMERICA

M. ZGUROVSKY, V. BAKHTINA[1]

Seven key developmental risks for Latin America are isolated: a) ecology and deforestation, b) natural disasters, c) drugs and crime, d) political stability, e) access to clean drinking water and sanitation facilities, f) health of the population and g) education level of the population. Selected factors are aggregated into an integrated risk index for the twenty three Latin American countries. Countries most susceptible to the indicated set of the threats are identified.

INTRODUCTION

Ample research covers a wide diversity of developmental risks as major causes for instability and crises in the world. World Economics Forum identified five main domains of risks: Economics, Geopolitics, Environment, Society and Technology, and highlighted two new topics on the agenda – food and energy crises [1]. At the same time, Human Development reports specifically emphasize the climate change as the defining human developmental issue of our generation [2].

To confront the challenges on the global scale, it is important to consider the differences among various regions, narrowing down the set of risks into a few most substantial threats for particular continents. When the areas of concern are targeted and quantified it is essential to integrate them into a standardized index to be able to systematically isolate most vulnerable spots and develop corrective measures. In this paper the authors attempt to separate specific developmental threats for Latin America and estimate their impact on sustainability of the twenty three selected countries.

The research and index aggregation are prepared based on "Sustainable development gauging matrix" methodology [3] which allows to estimate the Sustainability Index and global impact of the threats totality.

DEVELOPMENTAL RISK INDICATORS AND THEIR PROXIES FOR LATIN AMERICA

The 21st century forces humanity face the risk of global climate change and its consequences which include threats to biodiversity and ecosystems, escalating probability of natural disasters, limitation of access to clean drinking water and food, and impact on human health. The highest burden falls on the poorest coun-

[1] The views expressed herein are those of the individual contributor and do not necessarily reflect the views of IFC.

tries. The climate change could be one of the major impediments to reaching Millennium Development Goals [4], and could have a direct bearing on development prospects in the world [2]. Research of Global Risk Network demonstrated that all domains of developmental risks are interrelated and have to be considered jointly [1].

Latin America covers vast territories of land and represents one of major sources of biodiversity on the planet. At the same time, substantial exploitation of natural resources leads to deforestation, wild fires and destruction of natural reserves. Joint effort is needed to create effective policies to protect and nurture the continent's ecosystems, and to avoid detrimental consequences on the global scale. [5] Therefore, *Ecology and Deforestation* and *Natural Disasters* are selected as major threats for the continent.

According to the World Bank report, Latin America leads in a number of Millennium Development Goals. At the same time it is the continent with the world's largest income inequality facing the challenge to meet the poverty goal [6].

Another major problem in Latin America is crime with crime rates historically dominating the other regions. High level of inequality and urbanization escalate the level of crime and drug abuse [7], [8], [9]. *Crime and Drugs* factor is considered as a separate risk for Latin America.

The region still faces significant political instability and lack of actionable reforms in selected countries [5]. *Political Stability* is the next major risk.

Health of the Population and *Access to Clean Drinking Water* are important factors where Latin America is on track to meet developmental goals [6], [10], [11].

World Economic Forum on Latin America deemed the *Education Level of the Population* to be the top priority to lay foundation for sustainable development in the region [5].

In total, we distinguish seven specific risk factors which have the greatest impact on Latin American countries. These factors are a) *Ecology and Deforestation*, b) *Natural Disasters*, c) *Drugs and Crime*, d) *Political Stability*, e) *Access to Clean Drinking Water and Sanitation Facilities*, f) *Health of the Population*, and g) *Education Level of the Population* as a factor which amplifies the consciousness of the population to global problems and capability to make a change [4].

For each of the threats one or several proxies are assigned based on relevance and data availability. CO2 Emissions per capita and deforestation rate are used as a proxy for *Ecology and deforestation* (a). Disaster risk index is considered a measure for susceptibility to natural disasters (b). Three proxies are chosen for *Drugs and crime* factor (c): Annual prevalence of cocaine and cannabis abuse, and intentional homicide. Increase in urban population as percentage of total may also cause crime increase as a result of migration of poor population to the cities and limitation of access to basic needs. *Health of the population* (f) risk proxy at the moment is limited to a risk of HIV infection and measured by percentage of HIV affected population. It potentially can be expanded to other areas. Literacy rate is added as a proxy for *Education Level of the Population* (g). Appendix 1 gives a detailed description of particular proxies and scale of the threats.

Twenty three Latin American countries are identified for the research. Data points are normalized and aggregated. Aggregated vector of global threats is es-

timated for each country and remoteness of each country from the global set of threats is assessed[2]. The countries are clustered based on their remoteness from the entirety of threats.

SIMULATION RESULTS

The following eleven variables-threats are selected as input to the model:

a) HIV affected population (%) (HIV);
b) political stability (PSAW);
c) disaster risk index (DRI);
d) access to water supply, (AWS);
e) CO2 Emissions per capita (metric tons) (CO2);
f) deforestation rates (DR);
g) urban population (%) (UP);
h) intentional homicide per 100,000 people (IH);
i) annual prevalence of cocaine abuse as % of population 15-64 (COCAINE);
j) annual prevalence of cannabis abuse as % of population 15-64(CANNABIS);
k) literacy rate, adult total (% of people ages 15 and above (LR).

Let's determine cumulative impact of the global threats (1–11) on various Latin American countries and groups of countries. Based on quantitative inputs for stand-alone variables-threats, we apply methods of cluster analysis with the objective of separation of groups of countries with "close" characteristics with respect to the totality of threats [3]. For each country let's assign a vector

$$\vec{T}r_j = (\mathrm{HIV}, \mathrm{PSAW}, \mathrm{DRI}, \mathrm{AWS}, \mathrm{CO2}, \mathrm{DR}, \mathrm{UP}, \mathrm{IH}, \mathrm{COCAINE}, \mathrm{CANNABIS}, \mathrm{LR})$$

with the coordinates characterizing the degree of the corresponding threats (table 1):

The resulting data on every threat are normalized so that the values belong to an interval (0–1). For example, for a global threat LR :

$$LR^0 = 1 - \frac{LR - LR_{\min}}{LR_{\max} - LR_{\min}}.$$

After normalizing for the remaining global variables-threats, we derive a normalized vector

$$\vec{T}^0 r_j = (\mathrm{HIV}^0, \mathrm{PSAW}^0, \mathrm{DRI}^0, \mathrm{AWS}^0, \mathrm{CO2}^0, \mathrm{DR}^0, \mathrm{UP}^0, \mathrm{IH}^0,$$

$$\mathrm{COCAINE}^0, \mathrm{CANNAIBIS}^0, LR).$$

Here the value of 0 denotes the maximum threat, and 1 corresponds to the minimum threat. As a result, after normalizing, the closer the proximity of a threat, the closer its numeric value to zero, and on the contrary, the further the proximity of a threat, the closer its value to one.

[2] The distance to the totality of threats is based on Minkovsky norm.

Table 1

Rank	Country	Degree of remotness from totality of global threats	HIV	PSAV	DRI	AWS	LR	CO2	DR	UP	IH	Cocaine	Cannabis
Very Low Risk													
1	Uruguay	0.77	0.89	0.65	1.00	0.98	0.97	0.95	1.07	0.08	0.92	0.86	0.93
2	Costa Rica	0.66	0.94	0.69	0.98	0.98	0.95	0.95	0.35	0.38	0.91	0.81	0.96
3	Cuba	0.63	1.00	0.52	0.99	0.85	1.00	0.91	0.72	0.25	0.97	0.62	0.88
Low Risk													
4	Brazil	0.57	0.87	0.48	1.00	0.85	0.89	0.94	0.34	0.16	1.00	0.67	0.99
5	Paraguay	0.55	0.92	0.40	0.99	0.71	0.94	0.98	0.29	0.42	0.82	0.86	0.92
6	Argentina	0.50	0.87	0.49	1.00	0.79	0.97	0.87	0.35	0.10	0.86	0.86	0.77
Medium Risk													
7	Chile	0.49	0.94	0.67	0.98	0.92	0.96	0.85	0.47	0.12	0.98	0.14	0.48
8	Peru	0.48	0.87	0.32	0.97	0.75	0.88	0.97	0.39	0.27	0.92	0.67	0.90
9	Trinidad and Tobago	0.47	0.09	0.47	1.00	0.86	0.98	0.09	0.37	0.88	0.83	1.00	0.69
10	Bolivia	0.47	0.98	0.31	0.98	0.77	0.87	0.97	0.35	0.36	0.96	0.09	0.75
11	Mexico	0.46	0.94	0.42	0.95	0.85	0.92	0.84	0.34	0.24	0.81	0.81	0.76
12	Barbados	0.45	0.62	0.72	1.00	1.00	1.00	0.83	0.41	0.47	0.89	0.52	0.30
13	Colombia	0.42	0.86	0.18	0.98	0.89	0.93	0.95	0.39	0.27	0.09	0.62	0.89
14	Dominican Republic	0.42	0.71	0.53	0.98	0.79	0.87	0.90	0.41	0.33	1.00	0.57	0.69
15	Panama	0.41	0.78	0.52	0.99	0.87	0.92	0.93	0.39	0.29	0.86	0.43	0.66
16	Ecuador	0.41	0.94	0.32	0.96	0.71	0.91	0.93	0.20	0.37	0.73	0.43	0.87
High Risk													
17	Nicaragua	0.36	0.96	0.41	0.75	0.75	0.77	0.97	0.20	0.41	0.81	0.52	0.86
18	Honduras	0.36	0.60	0.41	0.09	0.87	0.80	0.97	0.04	0.54	1.00	0.57	0.93
19	Belize	0.33	0.47	0.52	0.98	0.76	0.75	0.89	0.41	0.52	1.00	0.67	0.36
Very High Risk													
20	Haiti	0.28	0.11	0.19	0.91	0.46	0.55	1.00	0.32	0.61	1.00	0.86	0.42
21	El Salvador	0.27	0.78	0.49	0.88	0.74	0.81	0.97	0.20	0.40	0.54	0.76	0.55
22	Guatemala	0.25	0.80	0.34	0.96	0.85	0.69	0.97	0.25	0.53	0.63	0.43	0.10
23	Venezuela	0.17	0.83	0.25	0.55	0.84	0.93	0.78	0.32	0.07	0.52	0.47	0.74

For each country lets assign a certain number $\left\|\vec{T}r_j\right\|$ which represents Minkovsky norm for a vector of normalized threats $\vec{T}^0 r_j$, where $p = 3$ and $n = 11$:

$$\left\|\vec{T}r_j\right\| = \sqrt[3]{\sum_{l=1}^{n} (\vec{T}^0 r_{jl})^3} \ .$$

Note, that generally, in the majority of practical cases, p is chosen to equal 2. Increasing the parameter increases response (sensitivity) of the model to the

change of each subcomponent of $\vec{T}^0 r_j$, and vise versa, its decrease smoothens (roughens) its sensitivity. That is why, based on data analysis from table 1, it is recommended to increase parameter p from 2 to 3 to increase sensitivity of the model to certain threats which have insignificant numerical values in comparison to others but are extremely important in the risk context.

Let's call number $\vec{T}^0 r_j$ the degree of remoteness from the totality of threats (1–11) for country j. Based on the computation of norms for the vector of threats $\left\|\vec{T}r_j\right\|$ for each country j [3] lets introduce a relation of order among country clusters (table 1)

$$K_k \prec K_j \Leftrightarrow \left\|\vec{T}r_k\right\| \le \left\|\vec{T}r_j\right\|.$$

The simulation results are provided in table 1.

Based on simulation results the set of twenty three countries is split into five clusters: Very Low Risk, Low Risk, Medium Risk, High Risk and Very High Risk.

Uruguay, Costa Rica and Cuba are falling to Very Low Risk category. The common characteristics of these three countries are low HIV rates, relatively stable political situation, low drug prevalence and intentional crime, low emissions level and deforestation rates.

It is interesting that Barbados fell into Medium Risk cluster while leading in political stability, access to water supply, showing low deforestation rate and quite high literacy rate. The reason is quite high HIV percentage, intentional crime and drug prevalence.

Brazil, Paraguay and Argentina form the next cluster of Low Risk. These countries are subject to approximately equivalent threats of natural disasters and approximately equal level of political stability. Paraguay has the lowest access to water supply but leads the cluster in terms of stopping the spread of HIV infection and higher literacy rate.

Chili, Peru, Trinidad, Bolivia, Mexico, Barbados, Colombia, Dominican Republic, Panama and Ecuador represent Medium Risk cluster. All countries in medium cluster represent low natural disaster risk and quite high literacy rate. Level of political stability varies broadly from 0.31 to 0.72 Medium Risk cluster faces increasing drug usage and deforestation rates. Among all countries Colombia faces the highest intentional homicide rate and lowest political stability.

Nicaragua, Honduras and Belize are in High Risk Category.

El Salvador, Guatemala and Venezuela show the closest proximity to the cumulated threats chosen. Mostly the result is influenced by one or a couple of single factors from the whole set of threats. For example, Haiti has the highest HIV percentage after Trinidad. It is one of the most turbulent countries at the continent compared to Venezuela and Colombia with lowest level of access to water supply and literacy rate. All countries in the cluster have serious problems with deforestation.

All variables-threats equitably contributed to the cumulated threats assessment. Possible interpretation is that even if a certain country is lagging behind in one or a couple of areas it can use its strengths and manage crisis efficiently. For example, even if Colombia has the lowest level of political stability and the high-

est homicide rate in the region, it has higher literacy rates, lower environmental risks and adequate infrastructure, what leads to believe that if the focus is shifted primarily to the domestic terrorism and homicide reduction, the situation will be significantly improved.

SUMMARY

Based exclusively on the set of risk factors and variables-threats proxies chosen, the results of the simulation do not look surprising. Aggregated index of global threats is computed for all the threats collectively and takes into account country current situation and the potential. The index allows to isolate the countries which can reduce stand alone threats using their strengths and the most vulnerable groups where all threats represent a problem.

The research can potentially take into account broader measures of political risk, drugs and crime data. Another enhancement can be done using extended health statistics.

APPENDIX 1. Developmental Risks Proxies detail interpretation and scale

Risk	Interpretation	Scale	Threat Direction
HIV, %	Percentage of population affected by HIV	[0; 100]	Increase in absolute value
Political Stability and Absence of Violence (PSAW)	The indicator is a measure of "perceptions of the likelihood that the government will be destabilized or overthrown by possibly unconstitutional and/or violent means, including domestic violence and terrorism." Low scores in this variable indicate that citizens cannot count upon continuity of government policy or the ability to peacefully select and replace those in power	[−2.5;2.5]	Decrease in index value (−2.5 worst governance, 0 average, 2.5 best governance)
Disaster Risk Index (DRI)	Measure of vulnerability of countries to three key natural hazards: (1) earthquake, (2) tropical cyclone, (3) flood. Index is based on number of casualties as % of weighted national population. [killed per millions inhabitants]. (Weighted average population (1980-2000), takes into account the actual population at the time the casualties were recorded. E.g. if most of the disasters happened in the early eighties, then the figure reflects the average population at that time)	$(0; +\infty)$	Increase in absolute value
Access to water supply (AWS)	The access to water supply is defined in terms of the types of technology and levels of service afforded. This included house connections, public standpipes, boreholes with hand pumps, protected dug wells, protected springs and rainwater collection; allowance was also made for other locally-defined technologies. "Reasonable access" was broadly defined as the availability of at least 20 liters per person per day from a	[0;100]	Decrease in absolute value

	source within one kilometer of the user's dwelling. Access to water, does not imply that the level of service or quality of water is "adequate" or "safe"; these terms were replaced with "improved" Index shown as % of population		
CO_2 Emissions per capita (metric tons)	CO_2 emissions divided by midyear population	$(0; +\infty)$	Increase in absolute value
Deforestation Rates (DR)	Deforestation – permanent conversion of natural forest area to other uses, including shifting cultivation, permanent agriculture, ranching, settlements, and infrastructure development on an average annual basis between 1990 and 2005. Deforestated areas do not include areas lagged but intended for regeneration, or areas degraded by fuel wood gathering, acid precipitation and wildfires. Negative numbers indicate increase in forest area. Measures the rate of change	$(-\infty;+\infty)$	Increase in absolute value
Urban Population, %	Urban Population as % of total	[0;100]	Increase in absolute value
Intentional Homicide per 100,000 people (IH)	Number of homicides per 100000 people	$(0; +\infty)$	Increase in absolute value
Annual Prevalence of Cocaine abuse as % of population 15–64	People consuming cocaine as % of total population	$(0; +\infty)$	Increase in absolute value
Annual Prevalence of Cannabis abuse as % of population 15–64	People consuming cannabis as % of total population	$(0; +\infty)$	Increase in absolute value
Literacy rate, adult total (% of people ages 15 and above)	Shows % of people ages 15 and above	$(0; +\infty)$	Decrease in absolute value

REFERENCES

1. *Global* Risks 2008, A global risk network report, World Economic Forum, January 2008 (weforum.org).
2. *Human* Development Report 2007/2008 Fighting climate change: Human solidarity in a divided world.
3. *Zgurovsky M.Z.* Sustainable development global simulation: Opportunities and threats to the planet. RUSSIAN JOURNAL OF EARTH SCIENCES, VOL. 9, ES2003, doi:10.2205/2007ES000273, 2007.
4. *Millennium* Development Goals, http://www.un.org/millenniumgoals/.

5. *World* Economic Forum on Latin America Cancún, Mexico, 15–16 April 2008. — http://www.weforum.org/en/events/ArchivedEvents/WorldEconomicForumonLatinAmerica2008/index.htm.
6. *World* bank web site http://ddp-ext.worldbank.org/ext/GMIS/gdmis. do?siteId=2&menuId=LNAV01REGSUB3.
7. *Basommbrio C.* Crime: A Latin American Challenge for Human Rights. Human Rights Dialogue 2.1 (Winter 1999) "Human Rights for All?", December 5, 1999.
8. *Weaver K., Maddaleno M.* Revista Panamericana de Salud Pública/Pan American Journal of Public Health, Volume 5, Numbers 4–5, April 1999, pp. 338–343(6), Pan American Health Organization (PAHO).
9. *Soares R., Naritomi J.* Understanding high crime rates in Latin America: The role of social and policy factors. July 2007, Harvard University, "Confronting crime and violence in Latin America: Crafting a public policy agenda" conference materials.
10. *World* Health Organization http://www.who.int/.
11. http://www.avert.org/aidslatinamerica.htm.
12. *Latin* America@Risk, A global Risk Network Briefing, World Economic Forum, 2007, United Nations Developmental Programme.
13. *Triesman D.* "Latin America at the crossroads", Latin Business Chronicle, April 2, 2007.
14. *Valente M.* "Environment — Latin America: Unsustainable Development". Second Latin American Congress on Natural Parks and other protected areas", Barlinoche, Oct 1, 2007.
15. *World* drug report, 2007, UN Office of drugs and crime.

Received 15.10.2008

From the Editorial Board: the article corresponds completely to submitted manuscript.